March 10, 2010

# The Mucool Beamline

C. Johnstone, I. Rakno, N. Mokov, M. Gerardi, B. Higgins

## *Description of Facility and MuCool Beamline*

The MuCOOL Beamline extracts, transports, and delivers 400-MeV $H^-$ beam directly from the Linac and Linac enclosure to a test facility, the MuCOOL Test Area (MTA) experimental hall. This experimental facility, located southwest of Wilson Hall, between the Linac berm and parking lot, will be used initially to support the MuCOOL R&D program and is designed to accept the full Linac beam pulse. The design concept for the MuCOOL facility is taken from an earlier proposal[1], but modifications to the existing proposal were necessary to accommodate high-intensity linac beam, cryogenics, and the increased scale of the cooling experiments. The MTA is one of the few such facilities in the world where a primary beam is available for experiments.

Most of the upstream MuCOOL beamline is housed in an enclosure contiguous with the Linac. The remaining downstream section of the beamline resides in a 30' beamline "stub" that opens into the experimental hall. A shield wall located beneath the access hatch separates the upstream section of the beamline from the downstream beamline stub and experimental hall. This wall effectively isolates the linac primary beam enclosure from all downstream enclosures preventing personnel access and exposure to radiation from linac operation. Upstream of the shield wall, the beamline is installed in a pre-existing section of the Linac enclosure and on an inclined ramp which raises the beamline from the Linac elevation to the elevation of the stub. The layout of the beamline starting from the extraction point in the Linac up to the entrance of the experimental hall is given in Figure 1.

## *The Beamline and Operational Modes*

The MTA beamline starts at extraction from the Linac, which begins in the first pulsed C magnet, UHB01A, just upstream of the 400-MeV Chopper. (The 2$^{nd}$ C magnet, which completes extraction ,is downstream of the Chopper.) Stationing, therefore, for this beamline begins at the upstream face of the first pulsed C magnet, which is defined as station Z=0 . The endpoint of beam transport is defined by the mode of operation and there are two modes. In the emittance mode, the beam is stopped in a low-intensity emittance beam absorber and for experiments it is a high-intensity beam absorber which is buried in berm downstream of the experimental hall. The emittance mode accepts up to 600 full Linac pulses per hour or 9.6 x $10^{15}$ protons/hr. In the experimental mode, beam is transported to experiments into the hall at a rate of 60 pulses/hr or 9.6 x $10^{14}$ protons/hour .

## *Longitudinal Shielding Beamline Areas*

The longitudinal shielding divides the beamline into nine areas described as a) Main Linac enclosure, b) a section of the Linac enclosure with an elevated (high) ceiling, c) a "ramp" which connects the main Linac enclosure the MTA "stub" elevationwise , d) an alcove section embedded in the primary shield wall which houses the beam stop (a critical device), e) the primary shield wall below the access hatch, f) the part of the MTA beamline contained in a ~10'x10' prefabricated concrete stub, g) the 20' x 40' MTA experimental hall, h) the region between the hall and primary beam absorber occupied by a 6' long beam pipe that connects the MTA hall to the final beam absorber, and, finally, i) the final beam absorber. Sections a, b, and c up to the shield wall are either partially (section a) or entirely installed on a slightly inclined floor (about 1.5 degrees upward). Additionally there is a 2.5' step down from the MuCOOL beamline stub into the experimental hall. Table I gives the stationing of the nine regions relative to the defined start point at the upstream face of the 1$^{st}$ C magnet. The following figures show the present beamline components in each of the nine areas with Figure 1 an overview of the facility.

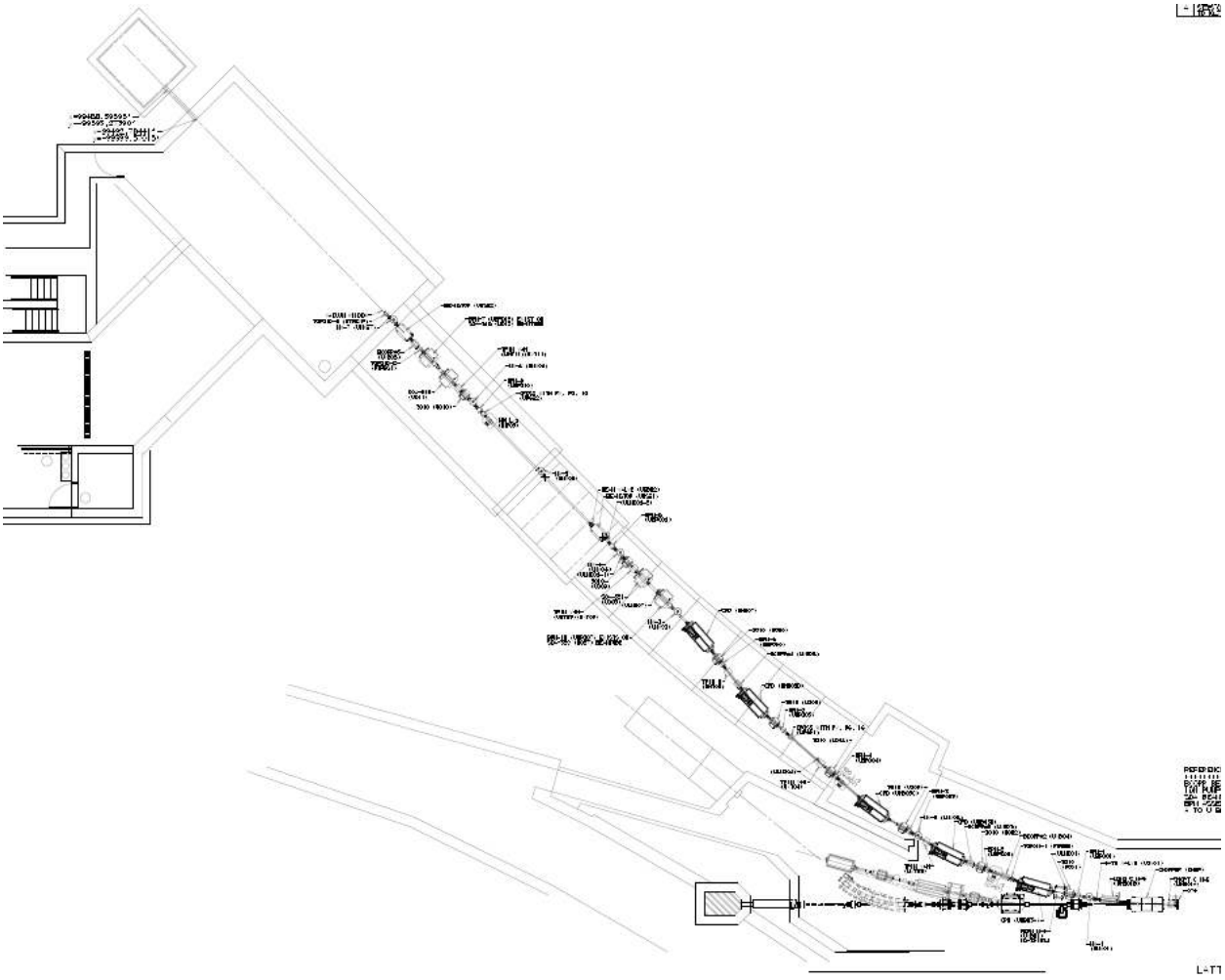


Figure 1. An overview of the entire facility. Details of the nine areas are given in the figures that follow.

**Table 1**: The nine longitudinal shielding sections

| Description | Stationing | Northing | Easting |
|---|---|---|---|
| Start | 0 | 99511.30274’ | 99617.141898’ |
| Main Linac Enclosure | 41.4’ | 99503.14412’ | 99596.90133’ |
| Linac High Ceiling | 54.7’ | 995494.50715 | 99585.16936 |
| Linac Access Ramp | 102.6’ | 99459.95440 | 99551.65122 |
| Beamstop alcove | 105.6’ | | |
| Shield Wall | 114.6’ | 99451.36564 | 99543.27872 |
| Beamline stub | 146.9’ | 99428.21164 | 99520.70773 |
| Experimental Hall | 186.9’ | 99399.56864 | 99492.78594 |
| Absorber beampipe | 193.4’ | | |
| Absorber | 202.9’ | | |

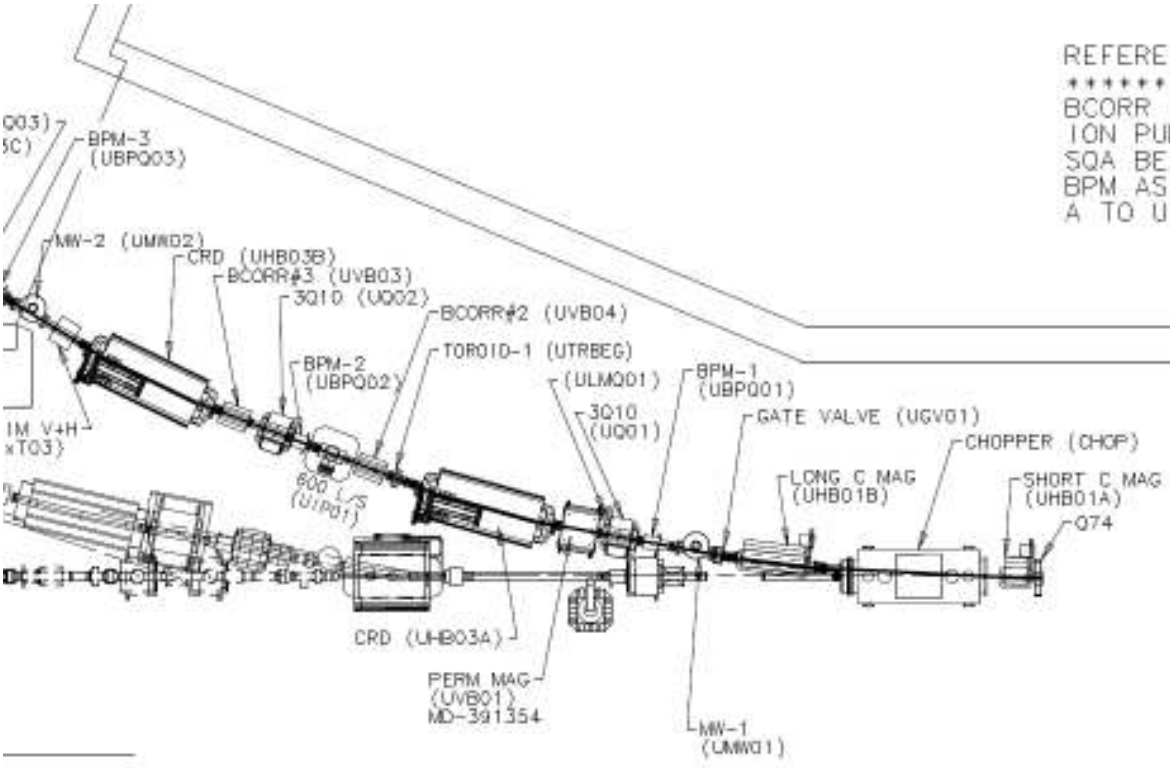



Figure 2. Plan view of area a is shown. The MTA beamline starts at the upstream end of the first pulsed C magnet which kicks the beam ~3 degrees to the west. Full separation from the 400 MeV transfer line is achieved at the downstream end of the 400 MeV electrostatic chopper. The Linac Main Enclosure section extends to the “old garage door” section located just upstream of UQ03.

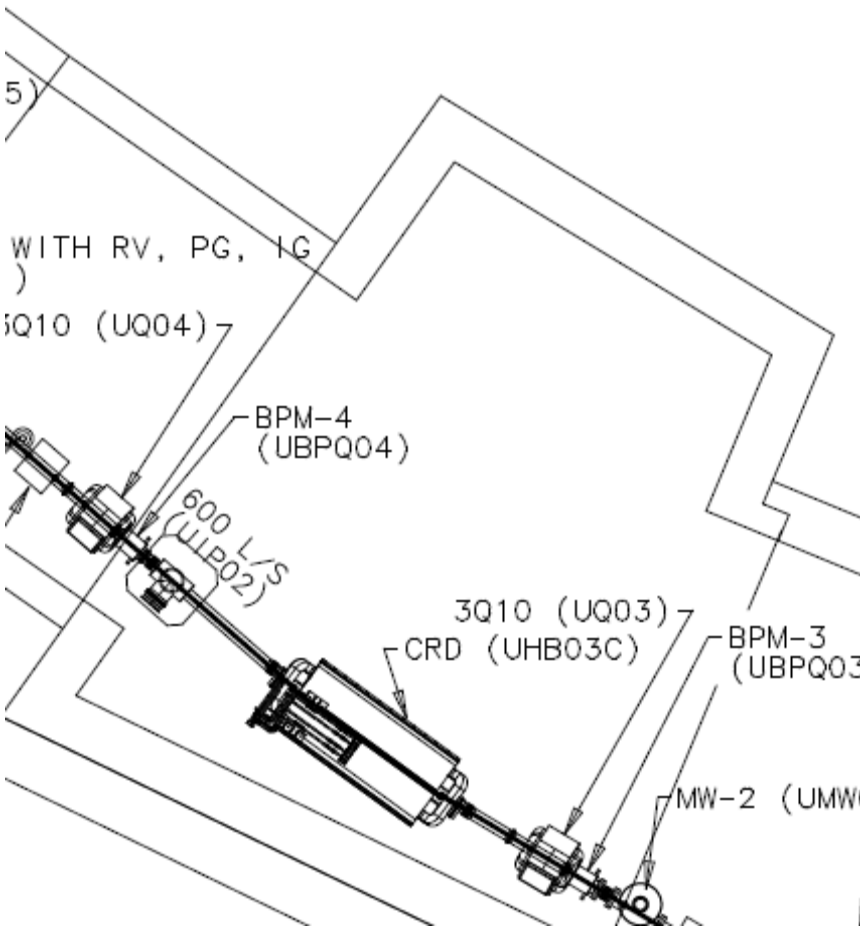



Figure 3. Just upstream of UQ03 the ceiling height increases with a corresponding decrease in longitudinal shielding. Area b, the Linac High Ceiling begins at the end of the previous section and ends at approximately the upstream face of UQ04.

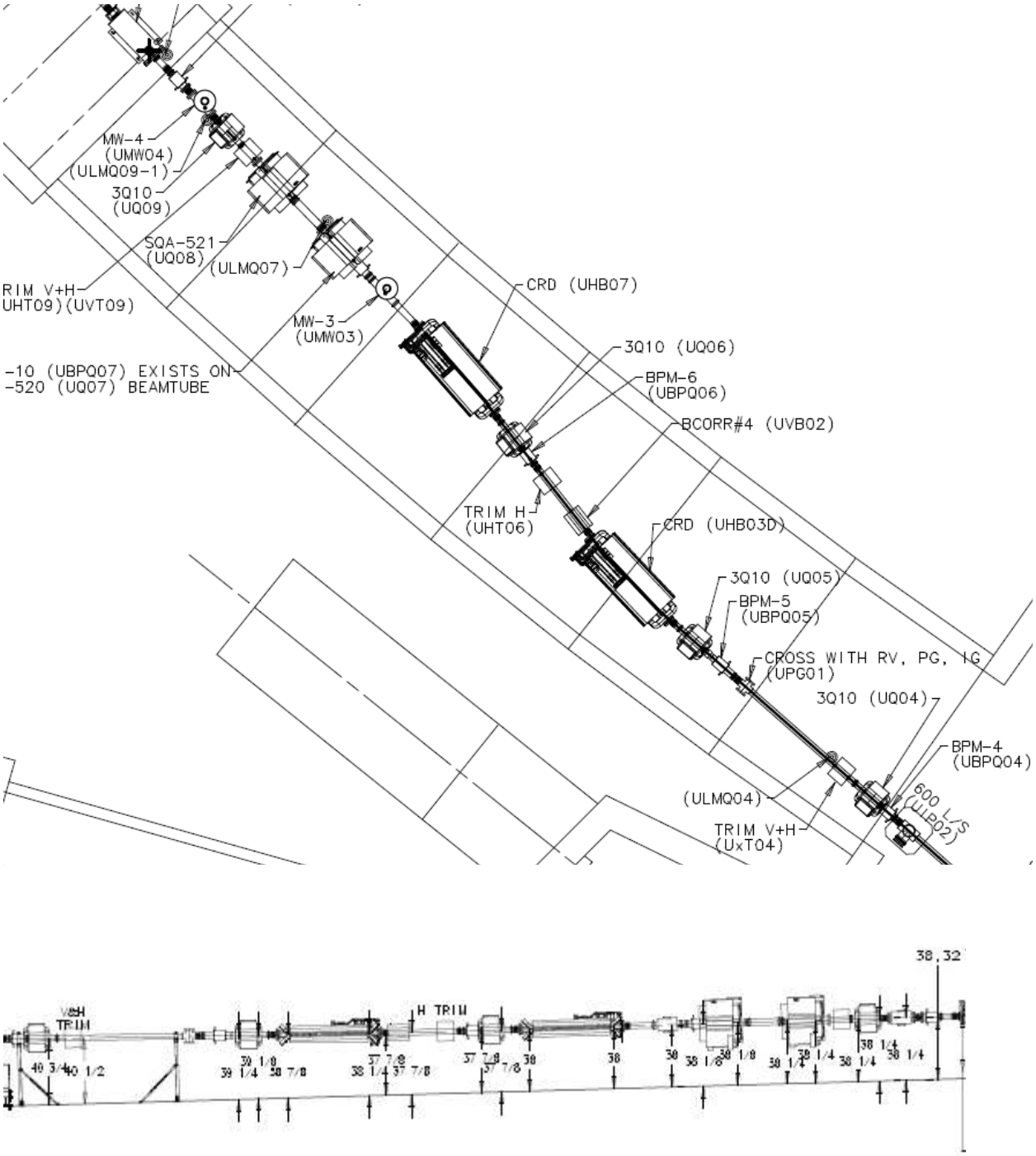



Figure 4. Plan and profile view of area c, the old Linac access ramp, which ends at the upstream face of the shield wall.

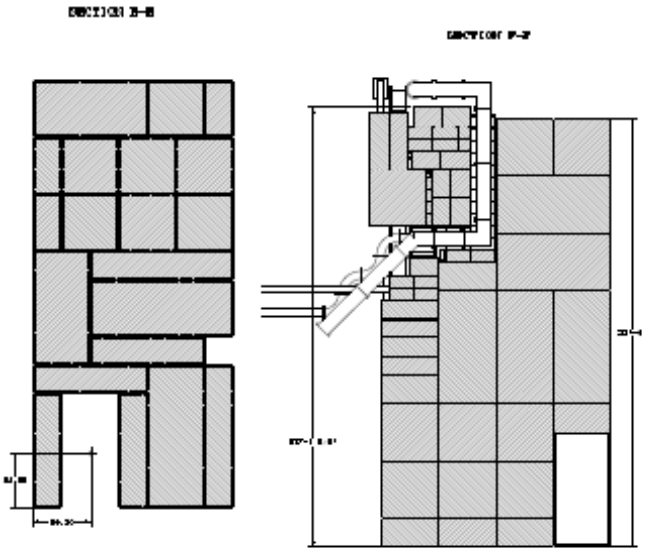


Figure 5. The alcove which houses the downstream part of the 1st beam stop is 5’ high, 4’ wide, and 3’ long and is inset in the shield wall, starting at the upstream face.

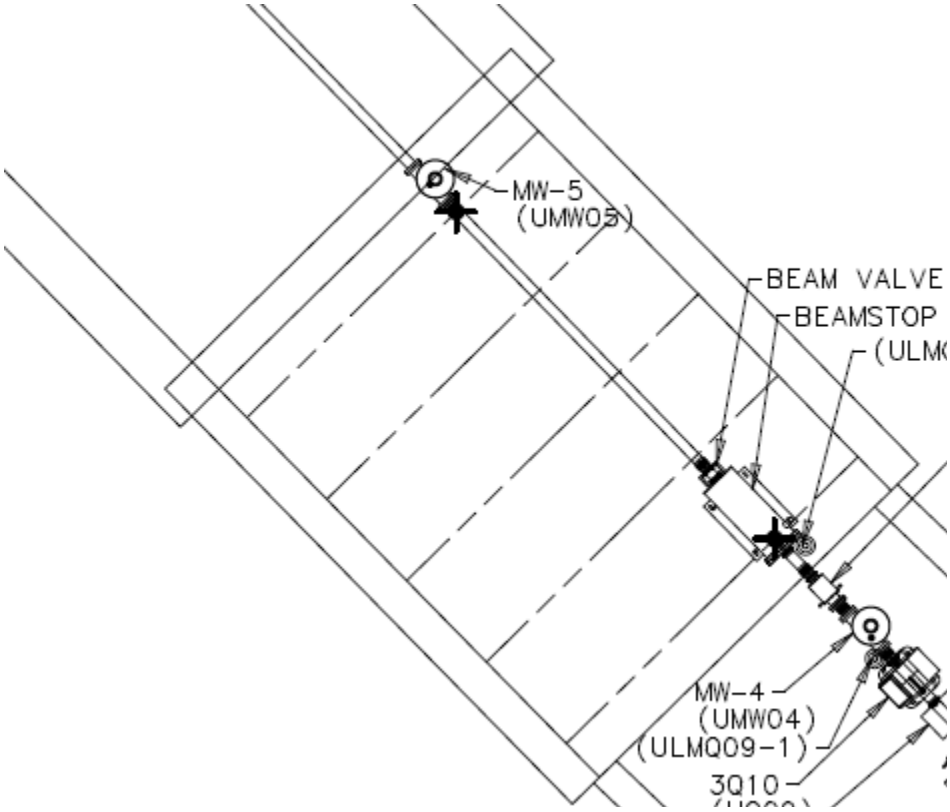



Figure 5. The shield wall is area e. The continuous longitudinal shielding under the hatch is broken into several sections by two waveguides in the shape of a dogleg and a cable tray. These sections are described in detail in another reference.

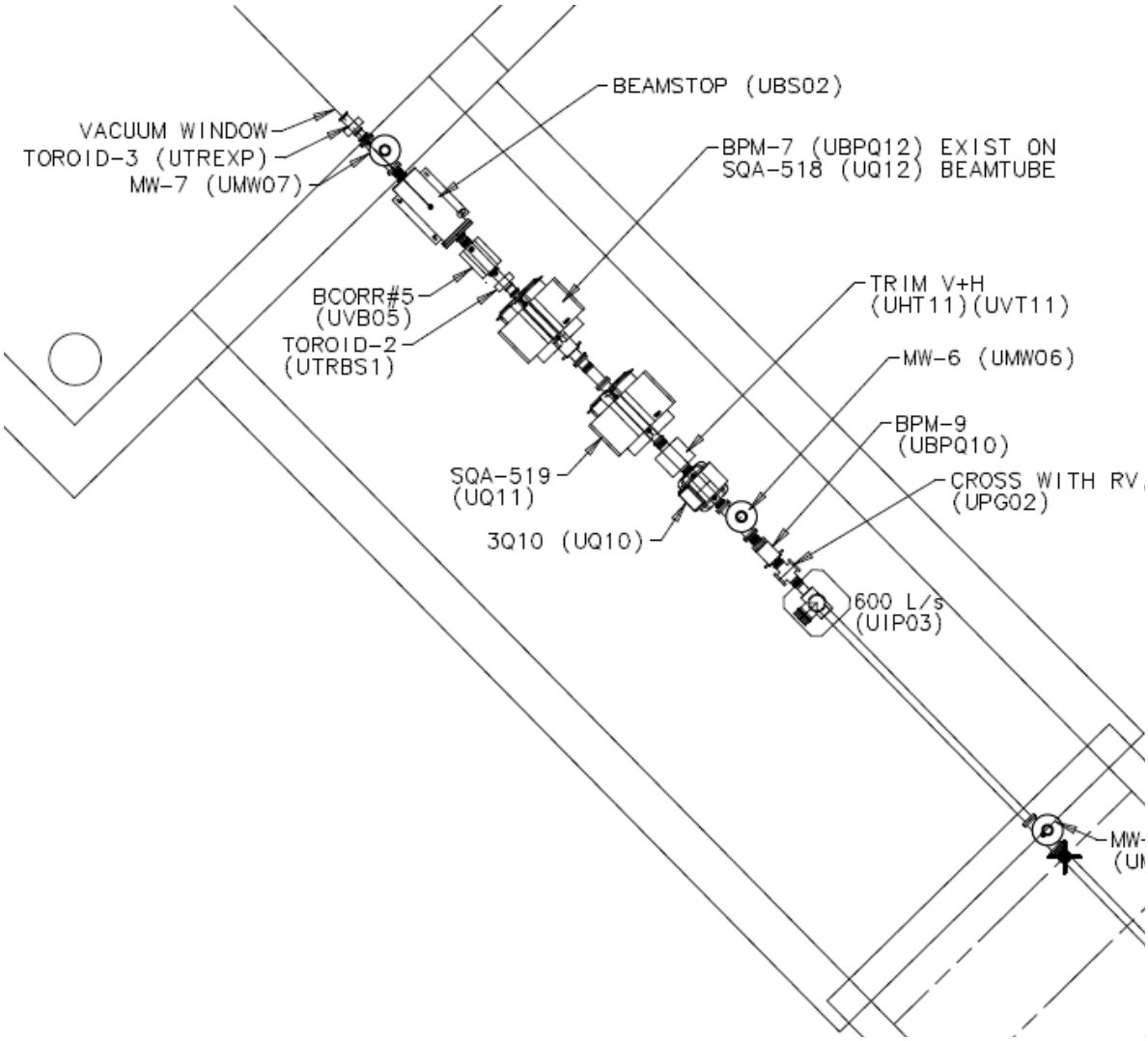



Figure 6. Area f is the ~10x10’ beam stub between the shield wall and the experimental hall This stub ends in a 2.5’ step down into the experimental hall.

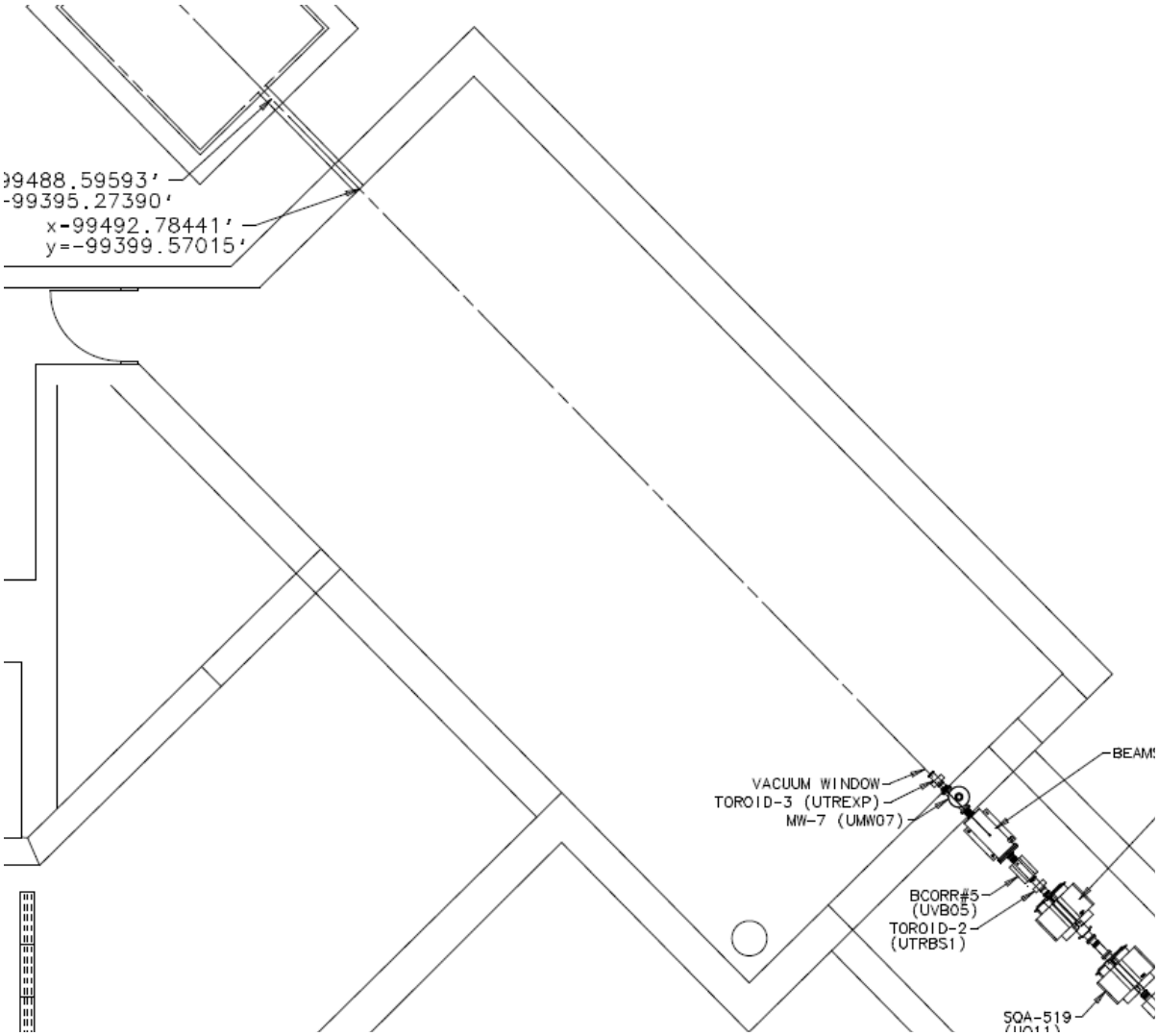



Figure 7. Area g is the 20' x 40' MTA experimental hall.

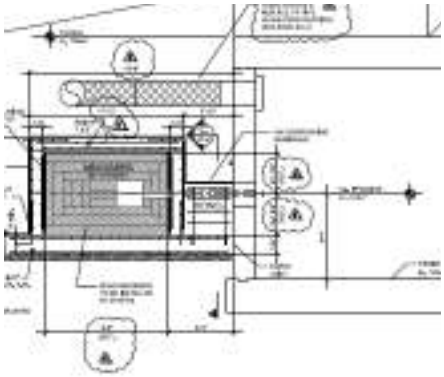
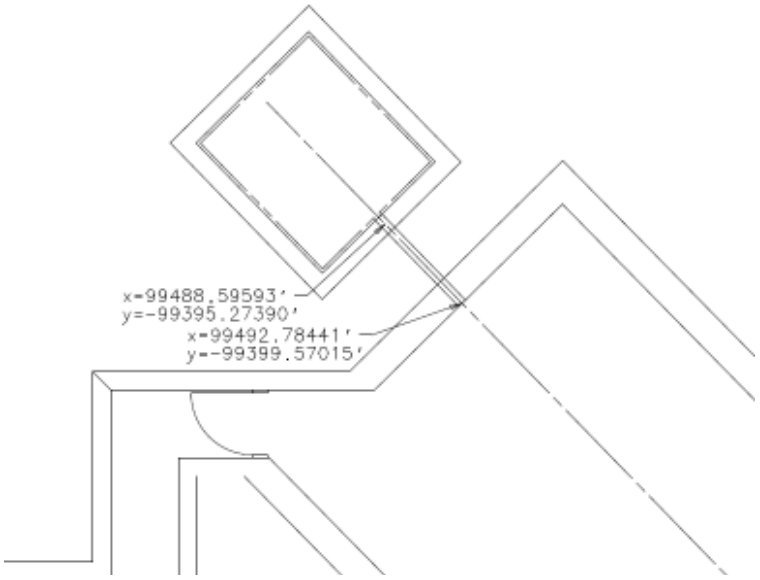


Figure 8. A 6' long beampipe, area h, connects the beamline from the downstream wall of the experimental hall to the beam absorber.



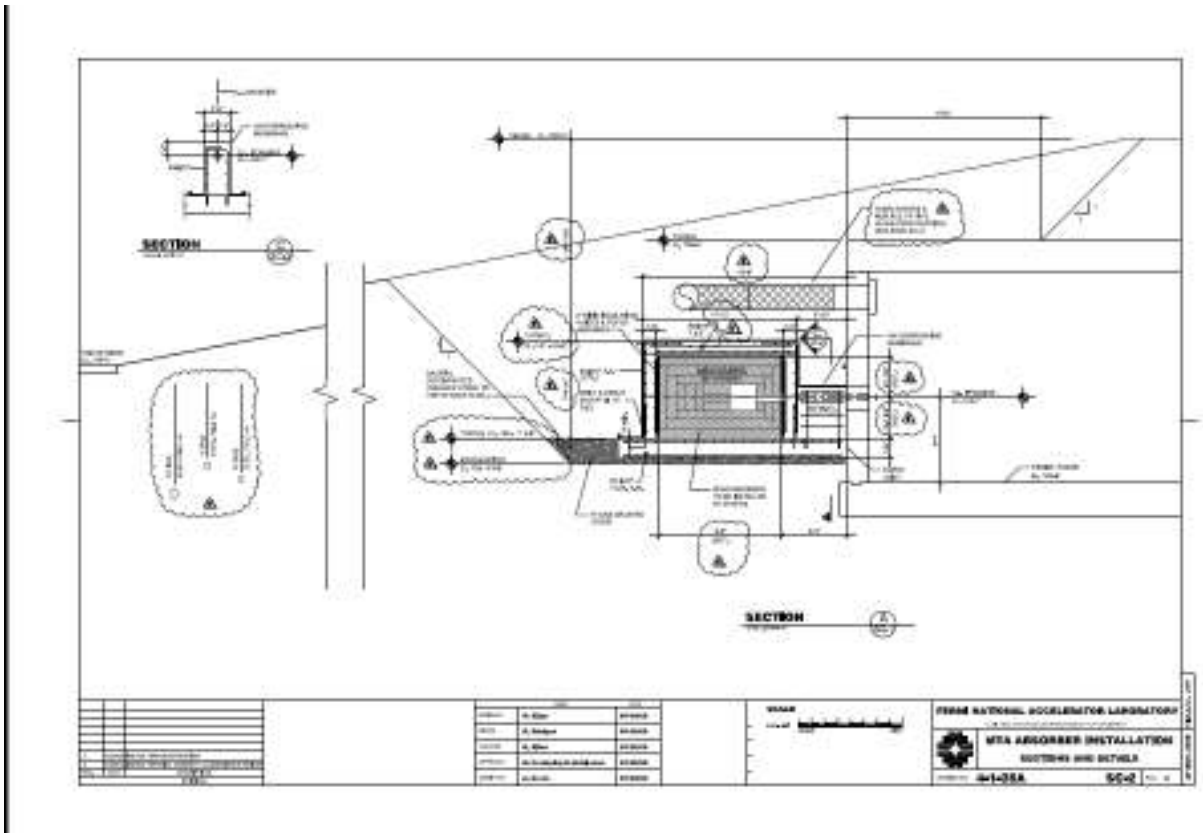




Figure 9. Plan and engineering profile view of area i, the final, high-intensity beam absorber.